

09/30/98  
jc540 U.S. PTO

Practitioner's Docket No. 390-008105-US (PAR)

**PATENT**

A

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

Box Patent Application  
Assistant Commissioner for Patents  
Washington, D.C. 20231

jc523 U.S. PTO  
09/163844  
09/30/98

**NEW APPLICATION TRANSMITTAL**

Transmitted herewith for filing is the patent application of  
Inventor(s): Christopher A. Hofmeister

**WARNING:** 37 C.F.R. § 1.41(a)(1) points out:

*"(a) A patent is applied for in the name or names of the actual inventor or inventors.*

*"(1) The inventorship of a nonprovisional application is that inventorship set forth in the oath or declaration as prescribed by § 1.63, except as provided for in § 1.53(d)(4) and § 1.63(d). If an oath or declaration as prescribed by § 1.63 is not filed during the pendency of a nonprovisional application, the inventorship is that inventorship set forth in the application papers filed pursuant to § 1.53(b), unless a petition under this paragraph accompanied by the fee set forth in § 1.17(i) is filed supplying or changing the name or names of the inventor or inventors."*

For (title): Substrate Transport Apparatus

**CERTIFICATION UNDER 37 C.F.R. 1.10\***

*(Express Mail label number is mandatory.)*

*(Express Mail certification is optional.)*

I hereby certify that this New Application Transmittal and the documents referred to as attached therein are being deposited with the United States Postal Service on this date EL067099585US, in an envelope as "Express Mail Post Office to Addressee," mailing Label Number 9/30/98, addressed to the: Assistant Commissioner for Patents, Washington, D.C. 20231.

Maureen Egan  
(type or print name of person mailing paper)

M Egan  
Signature of person mailing paper

**WARNING:** Certificate of mailing (first class) or facsimile transmission procedures of 37 C.F.R. 1.8 cannot be used to obtain a date of mailing or transmission for this correspondence.

**\*WARNING:** Each paper or fee filed by "Express Mail" **must** have the number of the "Express Mail" mailing label placed thereon prior to mailing. 37 C.F.R. 1.10(b).

*"Since the filing of correspondence under § 1.10 without the Express Mail mailing label thereon is an oversight that can be avoided by the exercise of reasonable care, requests for waiver of this requirement will **not** be granted on petition." Notice of Oct. 24, 1996, 60 Fed. Reg. 56,439, at 56,442.*

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## 1. Type of Application

This new application is for a(n)

(check one applicable item below)

- ☒ Original (nonprovisional)  
☐ Design  
☐ Plant

**WARNING:** Do not use this transmittal for a completion in the U.S. of an International Application under 35 U.S.C. 371(c)(4), unless the International Application is being filed as a divisional, continuation or continuation-in-part application.

**WARNING:** Do not use this transmittal for the filing of a provisional application.

**NOTE:** If one of the following 3 items apply, then complete and attach **ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF A PRIOR U.S. APPLICATION CLAIMED** and a **NOTIFICATION IN PARENT APPLICATION OF THE FILING OF THIS CONTINUATION APPLICATION**.

- ☐ Divisional.  
☐ Continuation.  
☐ Continuation-in-part (C-I-P).

## 2. Benefit of Prior U.S. Application(s) (35 U.S.C. 119(e), 120, or 121)

**NOTE:** A nonprovisional application may claim an invention disclosed in one or more prior filed copending nonprovisional applications or copending international applications designating the United States of America. In order for a nonprovisional application to claim the benefit of a prior filed copending nonprovisional application or copending international application designating the United States of America, each prior application must name as an inventor at least one inventor named in the later filed nonprovisional application and disclose the named inventor's invention claimed in at least one claim of the later filed nonprovisional application in the manner provided by the first paragraph of 35 U.S.C. 112. Each prior application must also be:

(i) An international application entitled to a filing date in accordance with PCT Article 11 and designating the United States of America; or

(ii) Complete as set forth in § 1.51(b); or

(iii) Entitled to a filing date as set forth in § 1.53(b) or § 1.53(d) and include the basic filing fee set forth in § 1.16; or

(iv) Entitled to a filing date as set forth in § 1.53(b) and have paid therein the processing and retention fee set forth in § 1.21(f) within the time period set forth in § 1.53(f).

37 C.F.R. § 1.78(a)(1).

**NOTE:** If the new application being transmitted is a divisional, continuation or a continuation-in-part of a parent case, or where the parent case is an International Application which designated the U.S., or benefit of a prior provisional application is claimed, then check the following item and complete and attach **ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED**.

**WARNING:** If an application claims the benefit of the filing date of an earlier filed application under 35 U.S.C. 120, 121 or 365(c), the 20-year term of that application will be based upon the filing date of the earliest U.S. application that the application makes reference to under 35 U.S.C. 120, 121 or 365(c). (35 U.S.C. 154(a)(2) does not take into account, for the determination of the patent term, any application on which priority is claimed under 35 U.S.C. 119, 365(a) or 365(b).) For a c-i-p application, applicant should review whether any claim in the patent that will issue is supported by an earlier application and, if not, the applicant should consider canceling the reference to the earlier filed application. The term of a patent is not based on a claim-by-claim approach. See Notice of April 14, 1995, 60 Fed. Reg. 20,195, at 20,205.

**WARNING:** When the last day of pendency of a provisional application falls on a Saturday, Sunday, or Federal holiday within the District of Columbia, any nonprovisional application claiming benefit of the provisional application must be filed prior to the Saturday, Sunday, or Federal holiday within the District of Columbia. See 37 C.F.R. § 1.78(a)(3).

- ☐ The new application being transmitted claims the benefit of prior U.S. application(s). Enclosed are ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

### 3. Papers Enclosed

- A. Required for filing date under 37 C.F.R. § 1.53(b) (Regular) or 37 C.F.R. § 1.153 (Design) Application

18 Pages of specification

8 Pages of claims

5 Sheets of drawing

**WARNING:** DO NOT submit original drawings. A high quality copy of the drawings should be supplied when filing a patent application. The drawings that are submitted to the Office must be on strong, white, smooth, and non-shiny paper and meet the standards according to § 1.84. If corrections to the drawings are necessary, they should be made to the original drawing and a high-quality copy of the corrected original drawing then submitted to the Office. Only one copy is required or desired. For comments on proposed then-new 37 CFR 1.84, see Notice of March 9, 1988 (1990 O.G. 57-62).

**NOTE:** "Identifying indicia, if provided, should include the application number or the title of the invention, inventor's name, docket number (if any), and the name and telephone number of a person to call if the Office is unable to match the drawings to the proper application. This information should be placed on the back of each sheet of drawing a minimum distance of 1.5 cm. (5/8 inch) down from the top of the page . . ." 37 C.F.R. 1.84(c)).

(complete the following, if applicable)

- ☐ The enclosed drawing(s) are photograph(s), and there is also attached a "PETITION TO ACCEPT PHOTOGRAPH(S) AS DRAWING(S)." 37 C.F.R. 1.84(b).
- ☐ formal
- ☐ informal

### B. Other Papers Enclosed

7 Pages of declaration and power of attorney

1 Pages of abstract

     Other

### 4. Additional papers enclosed

- ☐ Amendment to claims
- ☐ Cancel in this applications claims \_\_\_\_\_ before calculating the filing fee. (At least one original independent claim must be retained for filing purposes.)
- ☐ Add the claims shown on the attached amendment. (Claims added have been numbered consecutively following the highest numbered original claims.)
- ☐ Preliminary Amendment
- ☐ Information Disclosure Statement (37 C.F.R. 1.98)
- ☒ Form PTO-1449 (PTO/SB/08A and 08B)
- ☒ Citations

- ☐ Declaration of Biological Deposit
- ☐ Submission of "Sequence Listing," computer readable copy and/or amendment pertaining thereto for biotechnology invention containing nucleotide and/or amino acid sequence.
- ☐ Authorization of Attorney(s) to Accept and Follow Instructions from Representative
- ☐ Special Comments
- ☐ Other

**5. Declaration or oath (including power of attorney)**

*NOTE: A newly executed declaration is not required in a continuation or divisional application provided that the prior nonprovisional application contained a declaration as required, the application being filed is by all or fewer than all the inventors named in the prior application, there is no new matter in the application being filed, and a copy of the executed declaration filed in the prior application (showing the signature or an indication thereon that it was signed) is submitted. The copy must be accompanied by a statement requesting deletion of the names of person(s) who are not inventors of the application being filed. If the declaration in the prior application was filed under § 1.47, then a copy of that declaration must be filed accompanied by a copy of the decision granting § 1.47 status or, if a nonsigning person under § 1.47 has subsequently joined in a prior application, then a copy of the subsequently executed declaration must be filed. See 37 C.F.R. §§ 1.63(d)(1)-(3).*

*NOTE: A declaration filed to complete an application must be executed, identify the specification to which it is directed, identify each inventor by full name including family name and at least one given name, without abbreviation together with any other given name or initial, and the residence, post office address and country or citizenship of each inventor, and state whether the inventor is a sole or joint inventor. 37 C.F.R. § 1.63(a)(1)-(4).*

☒ Enclosed

Executed by

(check all applicable boxes)

- ☒ inventor(s).
- ☐ legal representative of inventor(s).  
37 CFR 1.42 or 1.43.
- ☐ joint inventor or person showing a proprietary interest on behalf of inventor who refused to sign or cannot be reached.
- ☐ This is the petition required by 37 CFR 1.47 and the statement required by 37 CFR 1.47 is also attached. See item 13 below for fee.

☐ Not Enclosed.

*NOTE: Where the filing is a completion in the U.S. of an International Application or where the completion of the U.S. application contains subject matter in addition to the International Application, the application may be treated as a continuation or continuation-in-part, as the case may be, utilizing ADDED PAGE FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION CLAIMED.*

- ☐ Application is made by a person authorized under 37 C.F.R. 1.41(c) on behalf of all the above named inventor(s).

(The declaration or oath, along with the surcharge required by 37 CFR 1.16(e) can be filed subsequently).

- ☐ Showing that the filing is authorized.  
(not required unless called into question. 37 CFR 1.41(d))

## 6. Inventorship Statement

**WARNING:** If the named inventors are each not the inventors of all the claims an explanation, including the ownership of the various claims at the time the last claimed invention was made, should be submitted.

The inventorship for all the claims in this application are:

☒ The same.

or

- ☐ Not the same. An explanation, including the ownership of the various claims at the time the last claimed invention was made,
- ☐ is submitted.
  - ☐ will be submitted.

## 7. Language

**NOTE:** An application including a signed oath or declaration may be filed in a language other than English. An English translation of the non-English language application and the processing fee, of \$130.00 required by 37 CFR 1.17(k) is required to be filed with the application, or within such time as may be set by the Office. 37 CFR 1.52(d).

☒ English

☐ Non-English

- ☐ The attached translation includes a statement that the translation is accurate. 37 C.F.R. 1.52(d).

## 8. Assignment

☒ An assignment of the invention to Brooks Automation Inc.

☒ is attached. A separate ☐ "COVER SHEET FOR ASSIGNMENT (DOCUMENT) ACCOMPANYING NEW PATENT APPLICATION" or ☒ FORM PTO 1595 is also attached.

☐ will follow.

**NOTE:** "If an assignment is submitted with a new application, send two separate letters—one for the application and one for the assignment." Notice of May 4, 1990 (1114 O.G. 77-78).

**WARNING:** A newly executed "CERTIFICATE UNDER 37 CFR 3.73(b)" must be filed when a continuation-in-part application is filed by an assignee. Notice of April 30, 1993, 1150 O.G. 62-64.

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## 9. Certified Copy

Certified copy(ies) of application(s)

Country	Appln. No.	Filed
Country	Appln. No.	Filed
Country	Appln. No.	Filed

from which priority is claimed

☐ is (are) attached.

☐ will follow.

NOTE: The foreign application forming the basis for the claim for priority must be referred to in the oath or declaration. 37 CFR 1.55(a) and 1.63.

NOTE: This item is for any foreign priority for which the application being filed directly relates. If any parent U.S. application or International Application from which this application claims benefit under 35 U.S.C. 120 is itself entitled to priority from a prior foreign application, then complete item 18 on the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

## 10. Fee Calculation (37 C.F.R. 1.16)

A. ☐ Regular application

CLAIMS AS FILED			
Number filed	Number Extra	Rate	Basic Fee 37 C.F.R. 1.16(a) \$790.00
Total			
Claims (37 CFR 1.16(c)) $23 - 20 = 3$	x	\$ 22.00	66.00
Independent			
Claims (37 CFR 1.16(b)) $6 - 3 = 3$	x	\$ 82.00	246.00
Multiple dependent claim(s), if any (37 CFR 1.16(d))	+	\$270.00	

☐ Amendment cancelling extra claims is enclosed.

☐ Amendment deleting multiple-dependencies is enclosed.

☐ Fee for extra claims is not being paid at this time.

NOTE: If the fees for extra claims are not paid on filing they must be paid or the claims cancelled by amendment, prior to the expiration of the time period set for response by the Patent and Trademark Office in any notice of fee deficiency. 37 CFR 1.16(d).

Filing Fee Calculation

\$ 1102.00

B. ☐ Design application

(\$330.00—37 CFR 1.16(f))

Filing Fee Calculation

\$ \_\_\_\_\_

C. ☐ Plant application

(\$540.00—37 CFR 1.16(g))

Filing fee calculation

\$ \_\_\_\_\_

[illegible]

- WARNING:** "Status as a small entity must be specifically established in each application or patent in which the status is available and desired. Status as a small entity in one application or patent does not affect any other application or patent, including applications or patents which are directly or indirectly dependent upon the application or patent in which the status has been established. The refiling of an application under § 1.53 as a continuation, division, or continuation-in-part (including a continued prosecution application under § 1.53(d)), or the filing of a reissue application requires a new determination as to continued entitlement to small entity status for the continuing or reissue application. A nonprovisional application claiming benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) of a prior application, or a reissue application may rely on a statement filed in the prior application or in the patent if the nonprovisional application or the reissue application includes a reference to the statement in the prior application or in the patent or includes a copy of the statement in the prior application or in the patent and status as a small entity is still proper and desired. The payment of the small entity basic statutory filing fee will be treated as such a reference for purposes of this section." 37 C.F.R. § 1.28(a)(2).

☐ Status as a small entity was claimed in prior application  
\_\_\_\_\_ / \_\_\_\_\_, filed on \_\_\_\_\_, from which benefit  
is being claimed for this application under:

- and which status as a small entity is still proper and desired.

- Filing Fee Calculation (50% of A, B or C above)**

**NOTE:** Any excess of the full fee paid will be refunded if small entity status is established and a refund request are filed within 2 months of the date of timely payment of a full fee. The two-month period is not extendable under § 1.136. 37 CFR 1.28(a).

(complete, if applicable)

- (Application Transmittal [4-1]—page 7 of 11)

RECEIVED 11-11-10

**13. Fee Payment Being Made at This Time**

☐ Not Enclosed

☐ No filing fee is to be paid at this time.  
(This and the surcharge required by 37 C.F.R. 1.16(e) can be paid subsequently.)

☒ Enclosed

☒ Filing fee \$ 1102.00

☒ Recording assignment  
(\$40.00; 37 C.F.R. 1.21(h))  
(See attached "COVER SHEET FOR  
ASSIGNMENT ACCOMPANYING NEW  
APPLICATION".) \$ 40.00

☐ Petition fee for filing by other than all the  
inventors or person on behalf of the inventor  
where inventor refused to sign or cannot be  
reached  
(\$130.00; 37 C.F.R. 1.47 and 1.17(l)) \$ \_\_\_\_\_

☐ For processing an application with a  
specification in  
a non-English language  
(\$130.00; 37 C.F.R. 1.52(d) and 1.17(k)) \$ \_\_\_\_\_

☐ Processing and retention fee  
(\$130.00; 37 C.F.R. 1.53(d) and 1.21(l)) \$ \_\_\_\_\_

☐ Fee for international-type search report  
(\$40.00; 37 C.F.R. 1.21(e)) \$ \_\_\_\_\_

NOTE: 37 CFR 1.21(f) establishes a fee for processing and retaining any application that is abandoned for failing to complete the application pursuant to 37 CFR 1.53(f) and this, as well as the changes to 37 CFR 1.53 and 1.78(a)(1), indicate that in order to obtain the benefit of a prior U.S. application, either the basic filing fee must be paid, or the processing and retention fee of \$ 1.21(f) must be paid, within 1 year from notification under § 53(f).

Total fees enclosed \$ 1142.00

**14. Method of Payment of Fees**

☒ Check in the amount of \$ 1142.00

☐ Charge Account No. \_\_\_\_\_ in the amount of  
\$ \_\_\_\_\_

A duplicate of this transmittal is attached.

NOTE: Fees should be itemized in such a manner that it is clear for which purpose the fees are paid. 37 CFR 1.22(b).

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## 15. Authorization to Charge Additional Fees

**WARNING:** If no fees are to be paid on filing, the following items should not be completed.

**WARNING:** Accurately count claims, especially multiple dependent claims, to avoid unexpected high charges, if extra claim charges are authorized.

☒ The Commissioner is hereby authorized to charge the following additional fees by this paper and during the entire pendency of this application to Account No. 16-1350.

☒ 37 C.F.R. 1.16(a), (f) or (g) (filing fees)

☒ 37 C.F.R. 1.16(b), (c) and (d) (presentation of extra claims)

**NOTE:** Because additional fees for excess or multiple dependent claims not paid on filing or on later presentation must only be paid or these claims cancelled by amendment prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency (37 CFR 1.16(d)), it might be best not to authorize the PTO to charge additional claim fees, except possibly when dealing with amendments after final action.

☒ 37 C.F.R. 1.16(e) (surcharge for filing the basic filing fee and/or declaration on a date later than the filing date of the application)

☒ 37 C.F.R. §§ 1.17(a)(1)–(5) (extension fees pursuant to § 1.136(a)).

☒ 37 C.F.R. 1.17 (application processing fees)

**NOTE:** ". . . A written request may be submitted in an application that is an authorization to treat any concurrent or future reply, requiring a petition for an extension of time under this paragraph for its timely submission, as incorporating a petition for extension of time for the appropriate length of time. An authorization to charge all required fees, fees under § 1.17, or all required extension of time fees will be treated as a constructive petition for an extension of time in any concurrent or future reply requiring a petition for an extension of time under this paragraph for its timely submission. Submission of the fee set forth in § 1.17(a) will also be treated as a constructive petition for an extension of time in any concurrent reply requiring a petition for an extension of time under this paragraph for its timely submission." 37 C.F.R. § 1.136(a)(3).

☐ 37 C.F.R. 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 C.F.R. 1.311(b))

**NOTE:** Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the notice of allowance. 37 CFR 1.311(b).

**NOTE:** 37 CFR 1.28(b) requires "Notification of any change in status resulting in loss of entitlement to small entity status must be filed in the application . . . prior to paying, or at the time of paying, . . . the issue fee. . . ." From the wording of 37 CFR 1.28(b), (a) notification of change of status must be made even if the fee is paid as "other than a small entity" and (b) no notification is required if the change is to another small entity.

(Application Transmittal [4-1]—page 9 of 11)

Approved for Filing

**16. Instructions as to Overpayment**

*NOTE: "... Amounts of twenty-five dollars or less will not be returned unless specifically requested within a reasonable time, nor will the payer be notified of such amounts; amounts over twenty-five dollars may be returned by check or, if requested, by credit to a deposit account." 37 C.F.R. § 1.26(a).*

- ☒ Credit Account No. 16-1350
- ☐ Refund

Reg. No. 42,841

Tel. No. ( 203 ) 259-1800

Customer No.



**SIGNATURE OF PRACTITIONER**

Janik Marcovici

*(type or print name of attorney)*

Perman & Green, LLP

**P.O. Address**

425 Post Road  
Fairfield, CT 06430

☐ **Incorporation by reference of added pages**

*(check the following item if the application in this transmittal claims the benefit of prior U.S. application(s) (including an international application entering the U.S. stage as a continuation, divisional or C-I-P application) and complete and attach the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED)*

- ☐ Plus Added Pages for New Application Transmittal Where Benefit of Prior U.S. Application(s) Claimed

Number of pages added \_\_\_\_\_

- ☐ Plus Added Pages for Papers Referred to in Item 4 Above

Number of pages added \_\_\_\_\_

- ☐ Plus added pages deleting names of inventor(s) named in prior application(s) who is/are no longer inventor(s) of the subject matter claimed in this application.

Number of pages added \_\_\_\_\_

- ☐ Plus "Assignment Cover Letter Accompanying New Application"

Number of pages added \_\_\_\_\_

☐ **Statement Where No Further Pages Added**

*(if no further pages form a part of this Transmittal, then end this Transmittal with this page and check the following item)*

- ☒ This transmittal ends with this page.

390-008105-US (PAR)

Patent Application Papers Of:

Christopher A. Hofmeister

For: SUBSTRATE TRANSPORT APPARATUS

## SUBSTRATE TRANSPORT APPARATUS

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

The present invention relates to a substrate transport apparatus and, more particularly, to a robot transport arm of a substrate transport apparatus.

#### 2. Prior Art

Various types of substrate transport apparatus are known in the prior art. Examples of substrate transport apparatus are described in U.S. Patents 5,404,894; 5,431,529 and 5,765,983.

### SUMMARY OF THE INVENTION

In accordance with a first embodiment of the present invention, a substrate transport apparatus is provided. The substrate transport apparatus comprises a drive section and a robot transport arm. The robot transport arm is mounted to the drive section. The robot transport arm has a wrist and an end effector to hold a substrate thereon. The end effector is rotatably mounted to the wrist, to rotate about the wrist. Rotation of the end effector about the wrist is slaved to the robot transport arm. The robot transport arm is adapted to transport substrates into and out of two generally side-by-side orientated substrate holding areas. The drive section is located in only one location relative to the holding areas.

In accordance with a second embodiment of the present invention, a substrate processing apparatus is provided. The substrate processing apparatus comprises a frame with a plurality of side-by-side substrate storage areas and a

robot transport arm pivotably mounted to the frame. The robot transport arm transports substrates between the substrate storage areas and a substrate holding area. The robot transport arm has an end effector and a wrist.

5 The end effector is pivotably mounted to the wrist of the robot transport arm. The robot transport arm is adapted to substantially rectilinearly move substrates into and out of at least two of the plurality of side-by-side substrate storage areas along axes of translation

10 corresponding to each of the two substrate storage areas. An axis about which the robot transport arm pivots relative to the frame stays in one location relative to the frame when the robot transport arm moves substrates into and out of each of the two substrate storage areas.

15 The end effector of the robot transport arm is slaved to the robot transport arm to rotate automatically about the wrist when the robot transport arm moves substrates into and out of each of the substrate storage areas.

In accordance with a first method of the present invention, a method for transporting a substrate into and out of a substrate holding area on a substrate processing apparatus is provided. The method comprises the steps of providing the substrate on an end effector of a transport arm, rotating the transport arm and moving the transport

20 arm. The transport arm is rotated about an axis of rotation at a shoulder of the transport arm in order to rotate the wrist about the axis of rotation. The transport is moved to radially displace the wrist of the transport arm relative to the axis of rotation at the

25 shoulder of the transport arm. The step of moving the transport arm rotates the end effector about the wrist to rotate the substrate about the axis of rotation at the shoulder of the transport arm in concert with rotation of the wrist about the axis of rotation at the shoulder of

30 the transport arm.

35

In accordance with a third embodiment of the present invention, a substrate transport apparatus is provided. The substrate transport apparatus comprises a robot transport arm, means for rotating the robot transfer arm, means for linearly displacing the end effector of the robot transport arm and a controller. The robot transport arm has an end effector to hold a substrate thereon. The means for rotating the robot transport arm rotate the arm about a first axis of rotation. The means for rotating the robot arm comprise a first drive mechanism being drivingly connected to the robot transport arm to rotate the robot transport arm as a unit about the axis of rotation. The means for displacing the end effector comprise a second driving mechanism drivingly connected to the robot transport arm to substantially radially displace the end effector relative to the axis of rotation. The controller controls the means for rotating the robot transport arm and the means for displacing the end effector to provide compound rotation, of the robot transport arm about the axis of rotation, with radial displacement of the end effector relative to the axis of rotation. The compound rotation of the robot transfer arm and radial displacement of the end effector result in general rectilinear translation of the substrate into and out of a substrate holding chamber.

In accordance with a second method of the present invention, a method for transporting a substrate into and out of a substrate holding area is provided. The method comprises the steps of providing the substrate on an end effector of a transport arm, rotating the transport arm as a unit about an axis of rotation and moving the end effector of the transport arm. The end effector is moved

to radially displace the end effector relative to the axis of rotation. The step of moving the end effector complements the step of rotating the transport arm about the axis of rotation to result in the substrate being  
5 substantially rectilinearly translated into and out of the substrate holding area.

In accordance with a third method of the present invention, a method for transporting substrates into and out of a substrate holding chamber. The method comprises  
10 the steps of placing an end effector on a transport arm in a first position, moving the end effector between the first position and a second position, and returning the end effector from the second position to the first position. The end effector is moved between the first  
15 position and the second position along a first path to axially translate a substrate on the end effector through an opening of the substrate holding chamber. The substrate is axially translated along the first path. The end effector is returned from the second position  
20 through the opening of the substrate holding chamber to the first position along a second path. A portion of the second path extending through the opening of the substrate holding chamber is different than a comparable portion of the first path extending through the opening  
25 of the substrate holding chamber.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing aspects and other features of the present invention are explained in the following description, taken in connection with the accompanying drawings,  
30 wherein:

Fig. 1 is a schematic top plan view of an apparatus for transporting substrates into and out of a processing



device, wherein the apparatus incorporates features of the present invention;

5 Figs. 2A-2B are a first pair of partial schematic top plan views of the apparatus shown in Fig. 1, showing a movable arm assembly in two positions when the arm assembly moves substrates held by the arm assembly into and out of a first substrate storage area;

10 Fig. 2C is another partial schematic top plan view of the apparatus shown in Fig. 1, showing the movable arm assembly in a third position when the arm moves into and out of the first substrate storage area without holding a substrate;

15 Figs. 3A-3B are a second pair of partial schematic top plan views of the of the apparatus shown in Fig. 1, showing the movable arm assembly in two positions when the arm assembly moves substrates held by the arm assembly into and out of a second substrate storage area;

20 Fig. 3C is yet another partial schematic top plan view of the apparatus shown in Fig. 1, showing the movable arm assembly in a third position when the arm moves into and out of the second substrate storage area without holding a substrate;

Fig. 4 is a schematic perspective view of the movable arm assembly of the apparatus shown in Fig. 1; and

25 Fig. 5 is a partial schematic top plan view of the apparatus shown in Fig. 1, showing the movable arm assembly extended in three different positions corresponding to three different substrate storage areas.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Fig. 1, there is shown a schematic top plan view of an apparatus 10 incorporating features of the present invention. Although the present invention will be described with reference to the single embodiment shown in the drawings, it should be understood that the present invention can be embodied in many alternate forms of embodiments. In addition, any suitable size, shape or type of elements or materials could be used.

The apparatus 10 is shown connected to load locks 12 of a substrate processing device 14. The processing device 14 is adapted to process substrates such as semiconductor wafers as is known in the art. Examples of substrate processing devices are described in US Patents 4,715,921 and 5,512,320 which are hereby incorporated by reference in their entireties. In alternate embodiments, the apparatus 10 could be configured to work with any suitable type of substrate processing device. The apparatus 10 generally comprises a frame 20, a car 22, a robot 24, a controller 52 and substrate cassettes 26. The apparatus 10 is adapted to move substrates, such as semiconductor wafers or flat panel display substrates, between the cassettes 26 and the load locks 12. The apparatus 10 employs the robot 24 to individually remove substrates from the cassettes 26 and insert the substrates into the load locks 12. When the processing device 14 finishes processing the substrates, the apparatus 10 is used to return the substrates from the load locks 12 to the cassettes 26. The apparatus 10 operates in atmospheric pressure, but could be used in other pressure conditions, including a vacuum. The apparatus 10 is adapted to hold a number of the cassettes 26.

The frame 20 is fixedly attached to the load locks 12 with the rear 13 of the frame 20 facing the front ends of the load locks 12. The frame 20 is adapted to removably support the cassettes 26 thereon. Fig. 1 shows the frame 20 supporting cassettes 26 which are used for holding 200mm semiconductor wafers. Referring also to Fig. 5, the frame 20 of the apparatus 10 may also support a second type of cassettes such as "open" cassettes 226 for holding 300mm semiconductor wafers. The cassettes 26 for 200mm wafers may hold thirteen or twenty-six semiconductor wafers. As shown in Fig. 1, each cassette 26 has a substrate access opening in the front 126 of the cassette 26. Substrates are transported into and out of the cassettes 26 through the front access opening along an axis X orientated substantially parallel to the sides 127 of the cassette 26. The cassettes are arranged generally side by side near the front 11 of the frame 20. The substrate access openings 126 of the cassettes 26 face in the same direction, towards the rear 13 of the frame 20. Thus, the axes X along which the substrates are transported into and out of the respective cassettes 26 are aligned substantially parallel to each other. At the rear 13 of the frame 20, a track area 21 extends the length of the frame 20. The car 22 is movably mounted on the track area 21 of the frame to move or roll between positions B and C along pathway A. A car drive mechanism 23 drivingly connects the car to the frame 20. The drive mechanism 23 is controlled by the controller 52 to controllably move the car 22 to different positions along the track area 21. One such car drive mechanism is described in US patent application No. 08/891,523, filed July 11, 1997 entitled "Robot Arm Relocation System" which is hereby incorporated by reference in its entirety. In alternate embodiments other types of robot arm relocation systems could be used. For example, the

robot arm may be rotatably mounted on a single axis of rotation.

The robot 24 is mounted to the car 22. Thus, the robot 24 moves with the car 22. The robot 24 generally comprises a movable arm assembly 25 and a drive section 27. In the preferred embodiment, the drive section 27 connects the movable arm assembly 25 to the car 22, though in alternate embodiments, the arm assembly may be mounted directly to the car with the drive section depending from the arm assembly. The drive section 27 is connected to the movable arm assembly 25 to independently rotate the arm assembly as a unit about a single axis of rotation and also to extend and retract the arm assembly 25. Furthermore, the drive section 27 can move the arm assembly 25 up and down relative to the frame 20 to vertically position the arm assembly as required. The arm assembly 25 is shown in a retracted position in Fig. 1. When the arm assembly 25 is extended it can have its end effector positioned inside the load locks 12 or cassettes 26 to pick-up or drop-off a substrate (see Figs. 2A and 3A).

Referring now to Fig. 4, there is shown a schematic perspective view of the movable arm assembly 25. In the embodiment shown, the arm assembly is an articulated arm assembly, such as disclosed in US Patent No. 5,431,529 or US Patent No. 5,765,983 which are hereby incorporated by reference in their entireties. The arm assembly 25 generally has three arm sections connected in series including an upper arm 31, a forearm 32, and a wrist extension 34. The upper arm 31 supports the arm assembly 25 from the drive section 27. The wrist extension 34 is connected to the upper arm 31 by the forearm 32 and includes an end effector section 44 at its distal end. The upper arm 31 of the movable arm assembly 25 is

mounted to the drive section 27 to rotate about a vertical axis of rotation Y1 at the shoulder 40 of the arm assembly. The forearm 32 is pivotably mounted to the upper arm 31 to form an elbow 41 of the arm assembly 25.

5 The forearm 32 rotates relative to the upper arm 31 about a vertical axis of rotation Y2 at the elbow 41 of the movable arm assembly 25. Opposite the elbow 41, the forearm 32 is pivotably connected to the wrist extension 34 to form a wrist 42 of the arm assembly. The wrist

10 extension 34 rotates relative to the forearm 32 about a vertical axis of rotation Y3 at the wrist 42. In the preferred embodiment, the end effector section 44 is located on the wrist extension 34 to hold a substrate S with its center generally aligned with a radial axis r.

15 The radial axis r extends through the axes of rotation Y1, Y3 at the shoulder 40 and wrist 42 (see Fig. 4). In alternate embodiments, the end effector may be located so that the center of the substrate held by the end effector is offset to the radial connecting the axes of rotation

20 at the shoulder and wrist.

Drive sections for actuating articulated arms are known in the art. The drive section 27, in the preferred embodiment, may be of a type which includes two co-axially mounted drive shafts 46, 48, although any other

25 suitable drive system may be used. The co-axial drive shafts 46, 48 are located to spin on the axis of rotation Y1 at the shoulder 40 of the movable arm assembly 25. The upper arm 31 is fixedly mounted to the first drive shaft 46 to turn in unison with the shaft 46 about the

30 axis Y1 at the shoulder 40. The second drive shaft 48 is operably connected by a transmission system 140 to the forearm 32 to rotate the forearm about the axis of rotation Y2 at the elbow 41 of the arm assembly 25. In the preferred embodiment, the transmission system is

35 located inside the upper arm 40. The drive shaft to

forearm transmission 140 may include a link and crank or otherwise a belt and pulley system imparting the rotation of the second drive shaft 48 to rotate the forearm 32 about the elbow 41. In an alternate embodiment, the transmission system may be located outside the upper arm. In another alternate embodiment, the drive shaft for rotating the forearm about the elbow may be located to directly drive the rotation of the forearm (e.g. the second drive shaft may be mounted to the upper arm at the elbow with the forearm directly mounted to the second drive shaft). The wrist extension 34 is operably connected to the forearm 32 by an elbow to wrist transmission system 142 which synchronously counter-rotates the wrist extension 34 about the axis of rotation Y3 at the wrist 42 in response to rotation of the forearm about the elbow 41. In the preferred embodiment, the elbow to wrist transmission system 142 is generally located inside the forearm 31. The elbow to wrist transmission system may comprise a link and offset crank or a belt and pulley system connecting the forearm 32 to the wrist extension 34 so that rotation of the forearm about the elbow 41 in one direction rotates the wrist extension 34 about the wrist 42 in an opposite direction. For example, clockwise rotation of the forearm 31 about the elbow 41 results in the wrist extension 32 rotating counter-clockwise about the wrist 42, and conversely, counter-clockwise rotation of the forearm 31 about the elbow 41 drives the wrist extension clockwise around the wrist 42. Thus, the rotation of the wrist extension 34 about the wrist 41 is slaved to the rotation of the forearm 31 about the elbow 41.

The drive section 27 is capable of independently turning the drive shafts 46, 48 in either direction at various rates of rotation. The controller 52 controls the direction and rate of rotation of the two drive shafts

46, 48 to manipulate the movable arm assembly 25. To rotate the movable arm assembly 25 as a unit about the axis of rotation Y1 at the shoulder 40, both drive shafts 46, 48 are rotated in unison. (e.g. To rotate the arm 25 clockwise about the shoulder 40, both shafts 46, 48 are rotated clockwise in unison.) Rotation of both shafts 46, 48 in unison rotates the arm assembly 25 as a unit about the shoulder 40 because there is no relative rotation between the upper arm 31 and the forearm 32. This rotation, indicated by the arrows T on Fig. 4, of the movable arm assembly 25 as a unit about the shoulder 40 is otherwise known as "T" movement of the movable arm assembly 25. Extension and retraction of the movable arm assembly 25 to displace the wrist 42 relative to the shoulder 41 substantially along a radial axis (a movement otherwise known as "R" movement of the arm assembly) is accomplished by counter-rotating the drive shafts 46, 48. Counter-rotation of the drive shafts 46, 48 in turn causes relative rotation between the upper arm 31 and forearm 32 and hence displacement of the wrist 42 relative to the shoulder 40. (e.g. In the embodiment shown, with the movable arm assembly 25 in an extended position, clockwise rotation of shaft 46 rotates the upper arm 31 clockwise about the shoulder 40, and counter-clockwise rotation of shaft 48 rotates the forearm 32 counter-clockwise about the elbow 41 thereby moving the wrist 42 towards the shoulder.) Counter-rotating the drive shafts 46, 48 at the same rate moves the wrist 42 relative to the shoulder 40 generally along a single radial axis as indicated by the arrows R in Fig. 4. As described previously, the rotation of the forearm 32 about the elbow 41 automatically counter-rotates the wrist extension 34 about the wrist 42. The elbow to wrist transmission synchronously counter-rotates the wrist extension 34 relative to the forearm 32 to maintain the center of a substrate held by the end effector

section 44 substantially aligned with the wrist 42 on the radial axis along which the wrist 42 is being translated during extension or retraction (i.e. "R" type movement) of the movable arm assembly 25.

5 The controller 52 also controls the drive section to substantially simultaneously rotate and extend or retract the movable arm assembly 25 in a compound "R" and "T" movement of the arm assembly. To achieve the compound "R" and "T" movement of the movable arm assembly 25, the  
 10 drive shafts 46, 48 are rotated at dissimilar rates. The dissimilar rates of rotation of the drive shafts result in dissimilar rates of rotation of the upper arm 31 and the forearm 32 which brings about rotation of the movable arm assembly 25 about the shoulder 40 (i.e. "T" movement)  
 15 compounded with extension/retraction of the arm assembly (i.e. "R" movement). The elbow to wrist transmission system which automatically counter-rotates the wrist extension 34 relative to the rotation of the forearm 32, maintains the wrist 42 and the center of the substrate on  
 20 the end effector section 44 generally aligned on an axis intersecting the axis of rotation Y1 at the shoulder 40. In other words, as the wrist 42 is rotated about the shoulder 40 by the compound "R" and "T" movement of the movable arm assembly 25, the wrist extension 34 is  
 25 automatically rotated about the wrist 42 so that the center of the substrate S on the end effector 44 rotates about the shoulder 40 at substantially the same rate as the wrist 42, and hence, the center of the shoulder 40, the center of the wrist 42 and the center of the  
 30 substrate S on the end effector 44 are points that generally remain co-linear. For example, when the arm assembly 25 is extended as shown in Fig. 3A, the wrist 42 and center of the substrate S held by the end effector are generally aligned with radial axis R3 which extends  
 35 through the shoulder 40. When the arm assembly 25 is



retracted as shown in Fig. 3B, the wrist 42 and center of the substrate S are generally aligned with radial axis R4 which again extends through the shoulder 40.

The procedure for moving substrates between the cassettes 26 and the load locks 12 is substantially as follows. Referring also to Figs. 2A-2C and 3A-3C, the first step of the procedure is to move the car 22 to place the shoulder 40, and hence the axis of rotation Y1 about which the movable arm assembly 25 rotates, at position D. Position D is located between the cassettes 26L, 26R. When the shoulder 40 of the arm assembly 25 is located at position D, the respective axes X1, X2 along which substrates are moved into and out of the two side by side cassettes 26L, 26R extend on both sides of the shoulder 40. After moving the movable arm assembly 25 to locate its shoulder 40 at position D, the arm assembly 25 is articulated to insert the end effector 44 into one of the side by side cassettes 26L, 26R to capture a substrate. With the shoulder 40 located at position D, the movable arm assembly 25 can be articulated to insert the end effector 44 into either of the two cassettes 26L, 26R without relocating the shoulder 40 relative to the cassettes. To insert the end effector 44 into the cassette 26L, 26R in the preferred embodiment, the controller 52 first rotates the arm entire assembly 25 as a unit about the shoulder 40 ("T" movement) to radially align the wrist 42 with the opening of the cassette 26L, 26R, (see Figs. 2C and 3C) and after the "T" movement is complete, extends the arm assembly 25 substantially along the radial ("R" movement) to insert the end effector 44 into the cassette 26L, 26R. In this embodiment, the location of the inner sides 127L, 127R (see Fig. 2) of cassettes 26L, 26R relative to the shoulder 40 at position D is such that the sides 127L, 127R do not interfere with translating the end effector 44

substantially along a single radial into the cassettes 26L, 26R. In alternate embodiments, where the location of the inner sides of the cassettes interfere with the "R" movement of the arm assembly 25, the end effector 44 is inserted into the cassettes by translating the end effector relative to the cassettes along an axis at a small angle relative to substrate removal/insertion axis X1, X2 corresponding to the particular cassette. This is accomplished by the controller 52 moving the arm assembly 25 in a compound "R" and "T" movement to provide a straight X axis movement of the center of the end effector 44. With the end effector 44 in the cassette 26L, 26R, the end effector 44 then captures a substrate S. Once the substrate S is captured by the end effector 44, the movable arm assembly 25 is articulated to remove the substrate S from the cassette 26L, 26R. The substrate S held by the end effector 44 is removed from the cassette 26L, 26R substantially along the corresponding substrate removal axis X1, X2. Thus, removal of the substrate S is along a different path than the insertion path of the end effector 44 into the cassette 26L, 26R (see Figs. 2B-2C and 3B-3C). To move the substrate S on the end effector 44 substantially along axis X1, X2, the movable arm assembly 25 is moved in a compound "R" and "T" movement (see Figs. 2A-2B and 3A-3B). The controller 52 controls the turn rate and direction of the two drive shafts 46, 48 to move the arm assembly 25 in a compound "R" and "T" movement which results in the substrate S being removed from the cassette 26L, 26R substantially along axis X1, X2. After the substrate S is out of the cassette 26L, 26R, the movable arm assembly 25 transports the substrate S into the load lock 12. If, as shown in Figs. 2B and 3B, the position D of the shoulder 40 is substantially in front of the load lock 12, the shoulder 40 stays in place in position D and the arm assembly 25 moves the substrate S

by undergoing a series of "T" movements and "R" movements. If position D of the shoulder 40 is not substantially in front but rather adjacent to the load lock 12, then the movable arm assembly 25 moves the substrate S into the load lock by undergoing a compound "R" and "T" movement with the shoulder staying in position D. Otherwise, to transport the substrate S into the load lock 12, the car 22 moves the shoulder 40 of the movable arm assembly 25 from position D to a different position to allow the arm assembly to insert the substrate into the load lock 12. Subsequent to the release of the substrate S in the load lock 12, the movable arm assembly 25 returns the end effector 44 to the cassette 26L, 26R as described above. The above sequence of steps is repeated as required until the cassette 26L, 26R is unloaded. In addition, the transfer of substrates between cassettes 26L, 26R and a load lock 12 need not be done one cassette at a time, because as noted previously, from position D, the movable arm assembly 25 may move substrates into and out of either the cassette 26L on the left or the cassette 26R on the right. Thus, during unloading of the cassettes, substrates may be removed sequentially from both the left and right cassettes 26L, 26R without relocating the shoulder 40 from position D. Alternatively, substrates may be removed from one cassette 26L, 26R on the first half of the transport cycle of the arm assembly 25 and different (i.e. processed) substrates may be returned to the adjoining cassette 26R, 26L on the return or second half of the transport cycle with the shoulder 40 of the arm assembly 25 staying in position D.

When returning substrates to their respective cassette 26L, 26R with the shoulder 40 of the arm assembly 25 located in position D, the substrate S held on the end effector 44 of the arm assembly 25 is also inserted into

the cassette 26L, 26R substantially along axis X1, X2. To move the substrate S into the cassette 26L, 26R substantially along axis X1, X2, the arm assembly 25 again performs a compound "R" and "T" movement substantially in reverse to the compound "R" and "T" movement performed to remove the substrate from the cassette along axis X1, X2 (see Figs. 2A-2B and 3A-3B). After the substrate S is released by the end effector 44 in the cassette 26L, 26R the end effector 44 is withdrawn from the cassette by merely retracting the arm assembly ("R" movement only). Thus, withdrawal of the end effector 44 after release of a substrate is along a different path than the insertion path of the substrate into the cassette 26L, 26R (see Figs. 2B-2C and 3B-3C). Figs. 2A-2C and 3A-3C show the movable arm assembly 25 moving substrates into and out of two cassettes 26L, 26R located at a side of the frame 20 of the apparatus, though the procedure and movements of the arm assembly 25 when moving substrates into and out of any two side by side cassettes 26 is substantially the same as shown in Figs. 2A-2C and 3A-3C and as described above.

Referring now to Fig. 5, the movable arm assembly 25 may also be used for moving substrates between three side by side "open" cassettes 226 and the load lock 12 when the arm 25 is located with its shoulder 40 (i.e. its axis of rotation Y1) at position D. As noted previously, the "open" cassettes 226 are generally used for holding 300mm semiconductor wafers. The shoulder 40 of the movable arm assembly 25 at position D is located between two of the cassettes 226 in generally in front of the load lock 12. For example, Fig. 5 shows that the shoulder 40 (i.e. position D) is located between the center cassette 226C and the right outer cassette 226ER. Fig. 5 shows the movable arm assembly 25 extended in three different positions with the end effector 44 located in each of the

three cassettes 226EL, 226C, 226ER. The procedure for moving the substrates between the three cassettes 226EL, 226C, 226ER and load locks 12 is substantially similar to the procedure described previously for moving substrates from two side by side cassettes 26L, 26R as shown in Figs. 2A-2C and 3A-3C. Once the movable arm assembly 25 is placed with its shoulder 40 in position D, the movable arm assembly is articulated in a compound "R" and "T" movement to move the substrate into and out of its corresponding cassette 226EL, 226C, 226ER substantially along the corresponding removal/insertion axis X3, X4, X5. Insertion and removal of the end effector 44 from the respective cassettes 226EL, 226C, 226ER may be either along a radial axis extending between the corresponding cassette 226EL, 226C, 226ER and the shoulder 40 of the arm assembly 25 or along an axis at a small angle to the removal/insertion axis X3, X4, X5 of the cassette.

In the prior art, robots of substrate transport apparatus moved substrates into and out of cassettes by locating the shoulder of the movable arm assembly directly in front of the cassette and moved the substrate by pure extension or retraction of the arm assembly (i.e. only "R" movement of the arm assembly). This required that the robot be relocated to the front of each cassette when a substrate was to be moved into or out of that particular cassette. The additional time required to relocate the arm assembly reduced the throughput of the apparatus of the prior art. Otherwise, the movable arm assembly of the robots in the prior art were provided with a separate and independent drive system to independently rotate the wrist extension of the movable arm assembly about the wrist which enabled these types of arm assemblies to move substrates into and out of cassettes without having to position the shoulder of the arm directly in front of the cassette. However, the

additional drive system required for the wrist extension of the arm assemblies increased the complexity and cost of the transport apparatus of the prior art. The present invention solves the problems of the prior art by  
5 allowing the movable arm assembly 25 to move substrates into and out of cassettes 26 without having to relocate the movable arm assembly 25 to the front of each cassette from or into which the substrates are being moved and without an additional independent drive system dedicated  
10 to independently rotate the wrist extensions about the wrist.

It should be understood that the foregoing description is only illustrative of the invention. Various alternatives and modifications can be devised by those skilled in the  
15 art without departing from the invention. Accordingly, the present invention is intended to embrace all such alternatives, modifications and variances which fall within the scope of the appended claims.

## CLAIMS

What is claimed is:

1. A method for transporting a substrate into and out of a substrate holding area on a substrate processing apparatus comprising the steps of:

providing the substrate on an end effector of a transport arm, the end effector being rotatably mounted to a wrist of the transport arm;

rotating the transport arm about an axis of rotation at a shoulder of the transport arm to rotate the wrist about the axis of rotation; and

moving the transport arm to radially displace the wrist of the transport arm relative to the axis of rotation at the shoulder of the transport arm, wherein the step of moving the transport arm rotates the end effector about the wrist to rotate the substrate about the axis of rotation at the shoulder of the transport arm in concert with rotation of the wrist about the axis of rotation at the shoulder of the transport arm.

2. A method as in Claim 1, wherein the steps of moving and rotating are harmonized with each other so that the substrate on the end effector is substantially rectilinearly translated with respect to the substrate holding area along an axis of translation extending through a substrate transport passage of the substrate holding area.

3. A method as in Claim 1, wherein the substrate processing apparatus comprises at least two of the

substrate holding areas located side by side to each other, the transport arm transporting substrates into and out of each of the two substrate holding areas, and wherein the axis of rotation at the shoulder of the transport arm stays in one location relative to the two substrate holding areas when the transport arm transports substrates into and out of each of the two substrate holding areas.

4. A method as in Claim 1, wherein the transport arm is an articulated arm comprising an upper arm link and a lower arm link and wherein the step of moving comprises independently rotating the lower arm link relative to the upper arm link.

5. A method for transporting a substrate into and out of a substrate holding area comprising the steps of:

providing the substrate on an end effector of a transport arm;

rotating the transport arm as a unit about an axis of rotation; and

moving the end effector of the transport arm to radially displace the end effector relative to the axis of rotation;

wherein the step of moving the end effector complements the step of rotating the transport arm about the axis of rotation to result in the substrate being substantially rectilinearly translated into and out of the substrate holding area.

6. A method for transporting substrates into and out of a substrate holding chamber comprising the steps of:



placing an end effector of a transport arm in a first position;

moving the end effector between the first position and a second position along a first path to axially translate a substrate on the end effector through an opening of the substrate holding chamber, the substrate being axially translated along the first path; and

returning the end effector from the second position through the opening of the substrate holding chamber to the first position along a second path, a portion of the second path extending through the opening of the substrate holding chamber being different than a comparable portion of the first path extending through the opening of the substrate holding chamber.

7. A method as in Claim 6, wherein the portion of the second path extending through the opening of the substrate holding chamber is generally described by a portion of an axis connecting a pivot axis of the transport arm at a shoulder of the transport arm to the substrate holding chamber.

8. A substrate transport apparatus comprising:

a drive section; and

a robot transport arm mounted to the drive section, the robot transport arm having a wrist and an end effector to hold a substrate thereon, the end effector being rotatably mounted to the wrist to rotate about the wrist, rotation of the end effector about the wrist being slaved to the robot transport arm;

wherein the robot transport arm is adapted to transport substrates into and out of two general side by side orientated substrate holding areas with the drive section being located in only one location relative to the two holding areas.

9. A substrate transport apparatus as in Claim 8, wherein the end effector is slaved to the robot transport arm so that, when the end effector rotates about the wrist relative to the robot transport arm, the substrate on the end effector and the wrist rotate about the drive section at a substantially equal rate.

10. A substrate transport apparatus as in Claim 8, wherein the robot transport arm is mounted to a drive shaft of the drive section, and wherein the end effector is slaved to the robot transport arm so that when the robot transport arm radially translates the end effector relative to the drive shaft the end effector is automatically rotated about the wrist.

11. A substrate transport apparatus as in Claim 10, wherein the end effector rotates about the wrist to rotate the substrate about the wrist so that as the substrate rotates about the wrist, the substrate, the wrist and the drive shaft remain generally aligned.

12. A substrate transport apparatus as in Claim 8, wherein the robot transport arm is an articulated arm comprising an upper arm link and a lower arm link, the upper arm link extending from a shoulder of the robot transport to an elbow of the robot transport arm and the lower arm link extending from the elbow to the wrist of the robot transport arm, and wherein the robot transport arm is mounted at the shoulder to a drive shaft of the drive section.

13. A substrate transport apparatus as in Claim 12, wherein the upper arm link is mounted to the drive shaft to rotate in unison with the drive shaft, and wherein the lower arm link is rotatably mounted to the upper arm link to rotate relative to the upper arm link.

14. A substrate transport apparatus as in Claim 12, wherein the robot transport arm includes means for automatically rotating the end effector about the wrist, and wherein the means for automatically rotating the end effector drivingly connect the lower arm link to the end effector slaving rotation of the end effector about the wrist to the rotation of the lower arm link about the elbow.

15. A substrate transport apparatus as in Claim 12, wherein the upper arm link and the lower arm link are rotated independently of each other to effect robot transport arm transport of substrates into and out of the two substrate holding areas.

16. A substrate transport apparatus as in Claim 8, wherein the robot transport arm transports substrates substantially rectilinearly into and out of each of the two substrate holding areas along axes of translation corresponding to each holding area.

17. A substrate transport apparatus as in Claim 16, wherein the axes of translation of the two substrate holding areas are substantially parallel to each other.

18. A substrate transport apparatus as in Claim 17, wherein when the robot transport arm transports substrates into and out of the two substrate holding areas the drive section is located between the axes of translation of the two substrate holding areas.

22. A substrate transport apparatus as in Claim 19, wherein the robot transport arm is an articulated arm comprising an upper arm and a lower arm, the upper arm being independently rotatable about the axis about which the robot transport arm pivots and the lower arm being independently rotatable relative to the upper arm.

23. A substrate transport apparatus comprising:

a robot transport arm with an end effector to hold a substrate thereon;

means for rotating the robot transport arm about a first axis of rotation, the means for rotating the robot transport arm comprising a first drive mechanism being drivingly connected to the robot transport arm to rotate the robot transport arm as a unit about the axis of rotation;

means for linearly displacing the end effector of the robot transport arm, the means for displacing the end effector comprising a second drive mechanism drivingly connected to the robot transport arm to substantially radially displace the end effector relative to the axis of rotation; and

a controller controlling the means for rotating the robot transport arm and the means for displacing the end effector to provide compound rotation of the robot transport arm about the axis of rotation with radial displacement of the end effector relative to the axis of rotation to result in general rectilinear

translation of the substrate into and out of a substrate holding chamber.

## ABSTRACT

1  
2 A substrate transport apparatus comprising a drive  
3 section and a robot transport arm. The robot transport  
4 arm is mounted to the drive section. The robot transport  
5 arm has a wrist and an end effector to hold the substrate  
6 thereon. The end effector is rotatably mounted to the  
7 wrist to rotate about the wrist. The rotation of the end  
8 effector about the wrist is slaved to the robot transport  
9 arm. The robot transport arm is adapted to transport  
10 substrates into and out of two general side-by-side  
11 orientated substrate holding areas with the drive section  
12 being located in only one location relative to the two  
13 holding areas.

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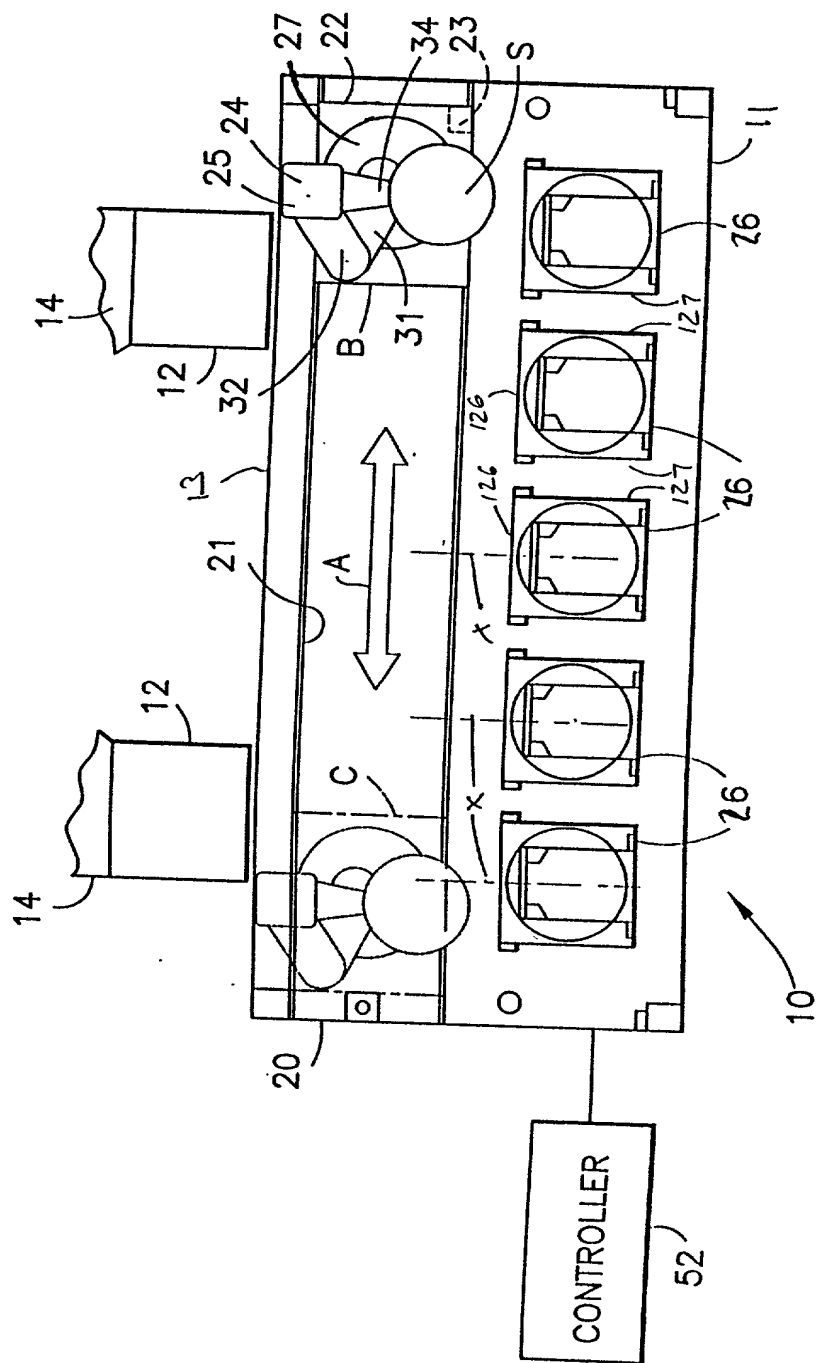
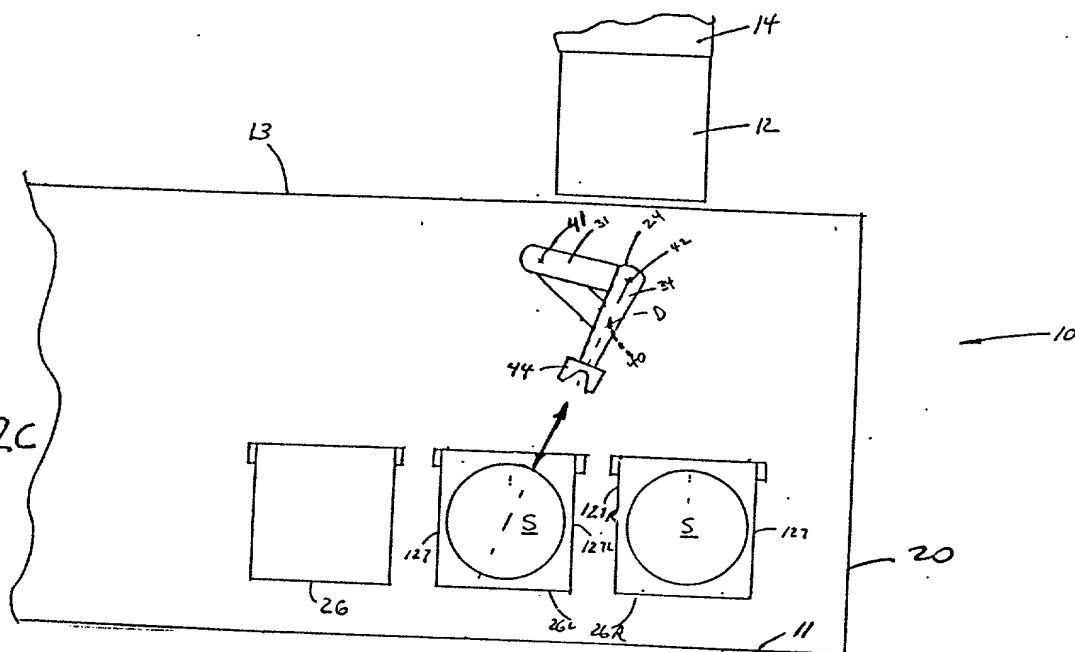
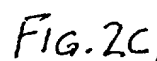
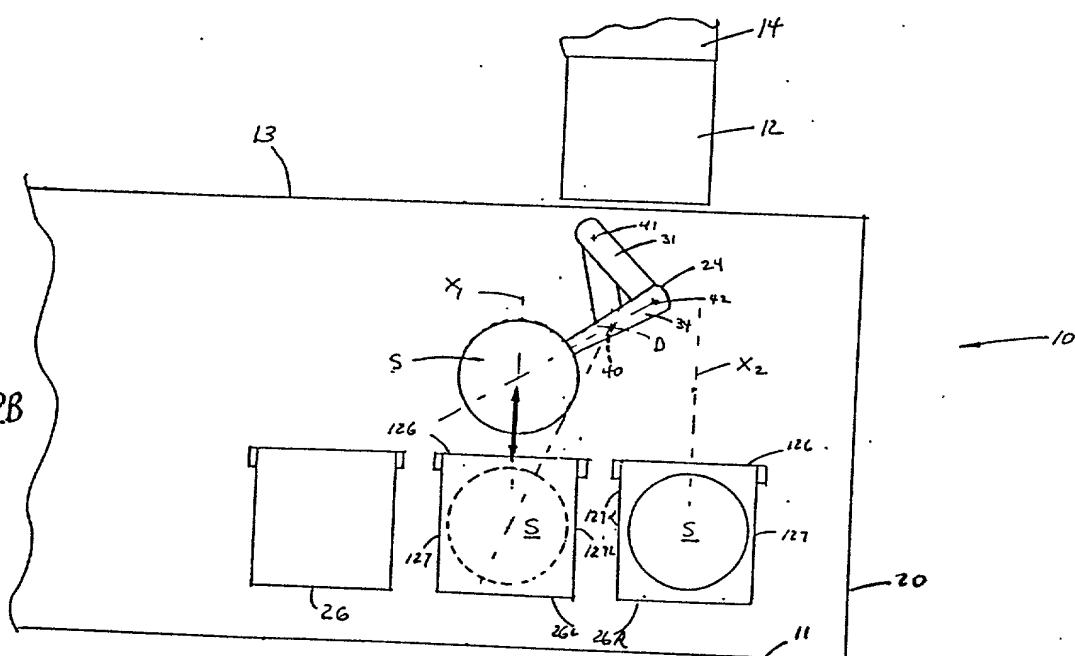
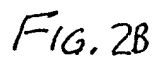
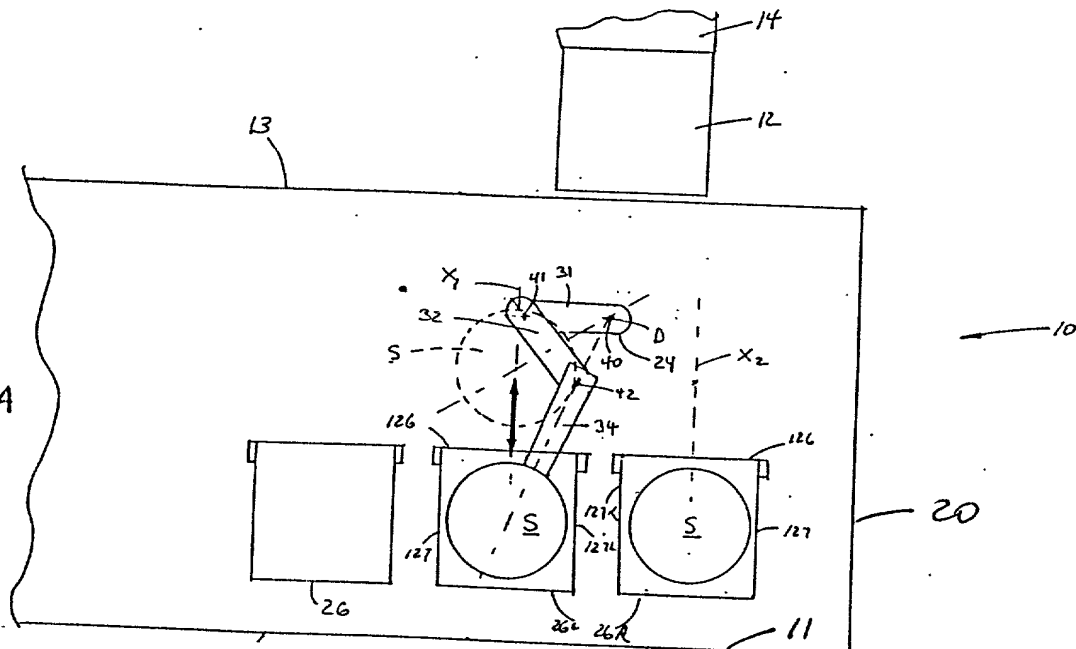
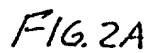
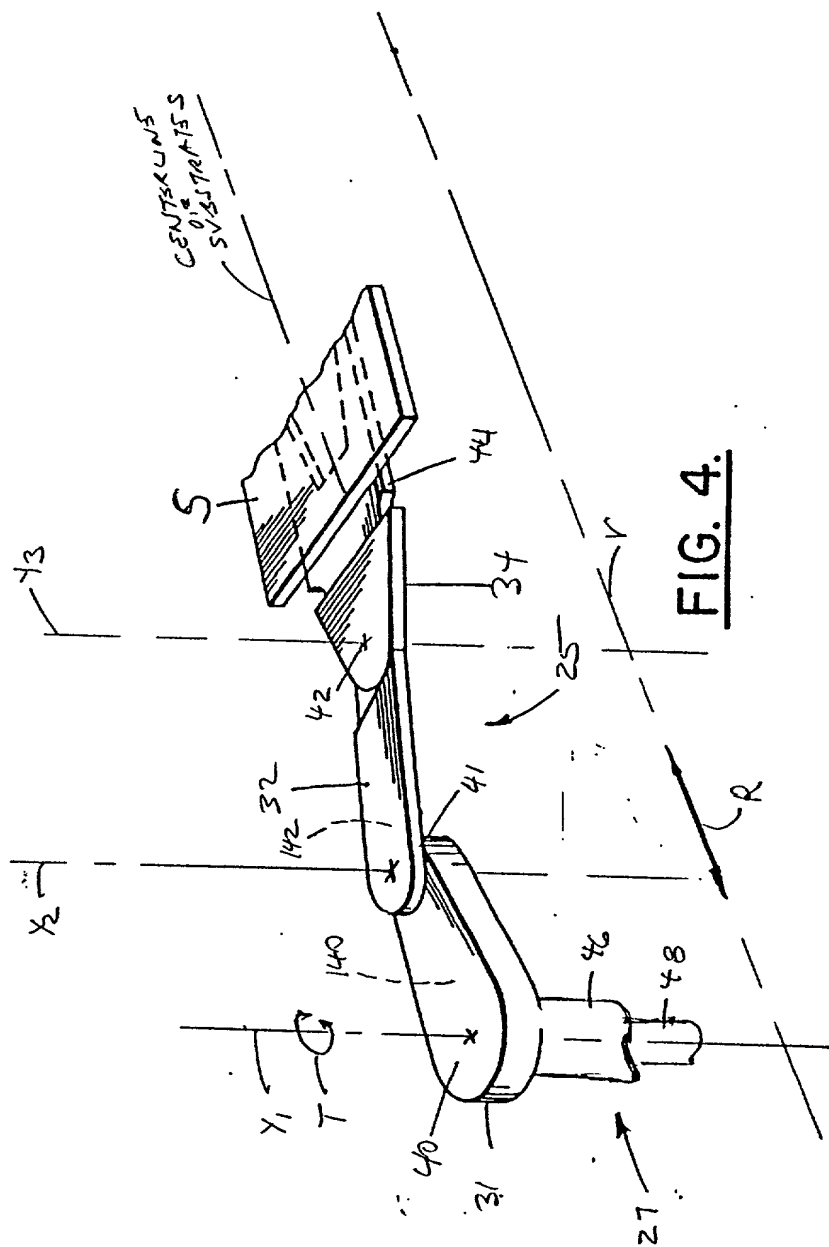


FIG. 1









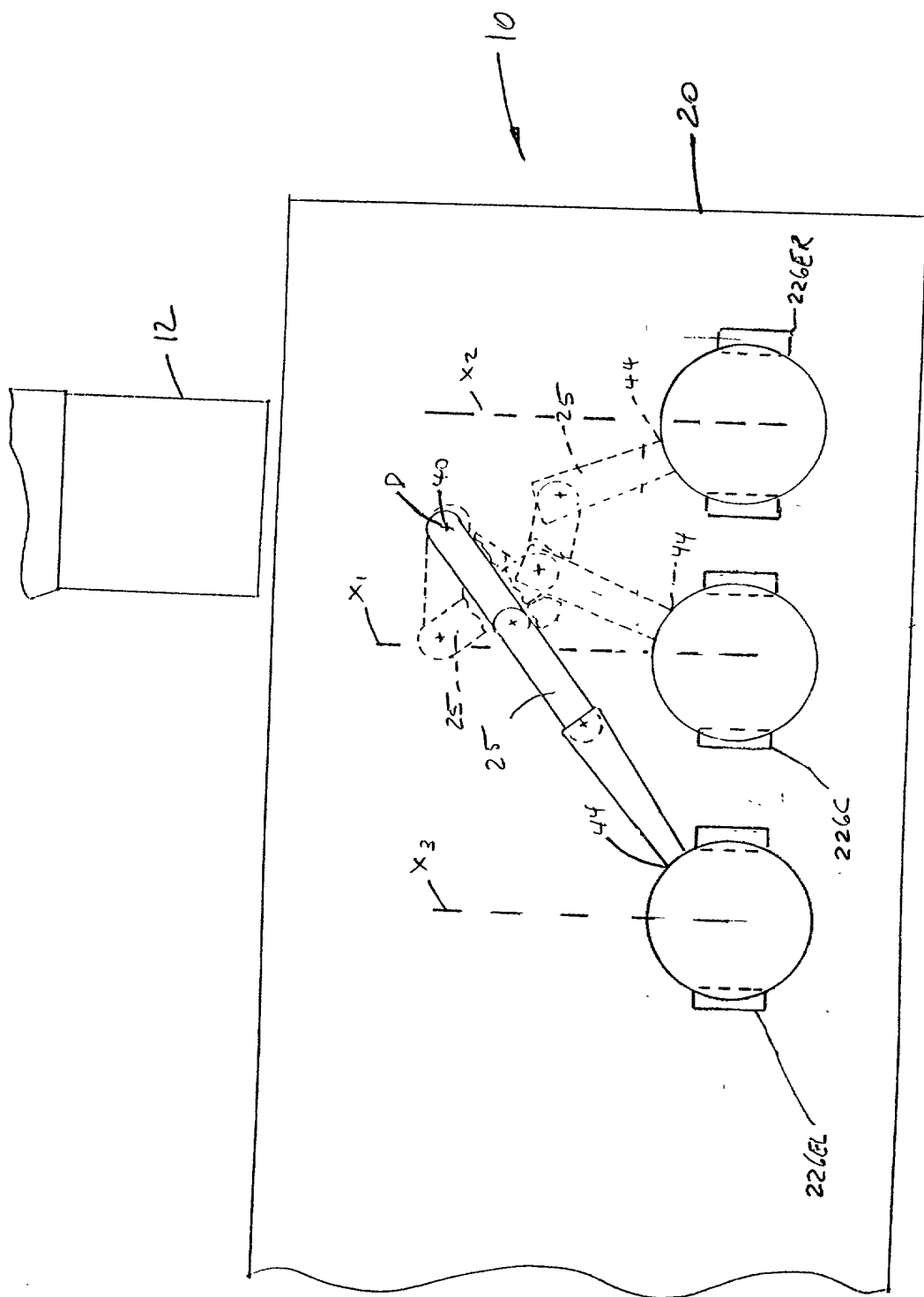


FIG. 5

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**COMBINED DECLARATION AND POWER OF ATTORNEY**

(ORIGINAL, DESIGN, NATIONAL STAGE OF PCT, SUPPLEMENTAL, DIVISIONAL,  
CONTINUATION, OR C-I-P)

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As a below named inventor, I hereby declare that:

**TYPE OF DECLARATION**

This declaration is of the following type:

(check one applicable item below)

- ☒ original.  
☐ design.  
☐ supplemental.

NOTE: If the declaration is for an International Application being filed as a divisional, continuation or continuation-in-part application, do not check next item; check appropriate one of last three items.

- ☐ national stage of PCT.

NOTE: If one of the following 3 items apply, then complete and also attach ADDED PAGES FOR DIVISIONAL, CONTINUATION OR C-I-P.

NOTE: See 37 C.F.R. § 1.63(d) (continued prosecution application) for use of a prior nonprovisional application declaration in the continuation or divisional application being filed on behalf of the same or fewer of the inventors named in the prior application.

- ☐ divisional.  
☐ continuation.

NOTE: Where an application discloses and claims subject matter not disclosed in the prior application, or a continuation or divisional application names an inventor not named in the prior application, a continuation-in-part application must be filed under 37 C.F.R. § 1.53(b) (application filing requirements — nonprovisional application).

- ☐ continuation-in-part (C-I-P).

**INVENTORSHIP IDENTIFICATION**

**WARNING:** If the inventors are each not the inventors of all the claims, an explanation of the facts, including the ownership of all the claims at the time the last claimed invention was made, should be submitted.

My residence, post office address and citizenship are as stated below, next to my name. I believe that I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter that is claimed, and for which a patent is sought on the invention entitled:

**TITLE OF INVENTION**

Substrate Transport Apparatus

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## SPECIFICATION IDENTIFICATION

the specification of which:

(complete (a), (b), or (c))

(a) ☒ is attached hereto.

NOTE: "The following combinations of information supplied in an oath or declaration filed on the application filing date with a specification are acceptable as minimums for identifying a specification and compliance with any one of the items below will be accepted as complying with the identification requirement of 37 CFR 1.63:

"(1) name of inventor(s), and reference to an attached specification which is both attached to the oath or declaration at the time of execution and submitted with the oath or declaration on filing;

"(2) name of inventor(s), and attorney docket number which was on the specification as filed; or

"(3) name of inventor(s), and title which was on the specification as filed."

Notice of July 13, 1995 (1177 O.G. 60).

(b) ☐ was filed on \_\_\_\_\_, as ☐ Serial No. 0 / \_\_\_\_\_  
or ☐ \_\_\_\_\_  
and was amended on \_\_\_\_\_ (if applicable).

NOTE: Amendments filed after the original papers are deposited with the PTO that contain new matter are not accorded a filing date by being referred to in the declaration. Accordingly, the amendments involved are those filed with the application papers or, in the case of a supplemental declaration, are those amendments claiming matter not encompassed in the original statement of invention or claims. See 37 CFR 1.67.

NOTE: "The following combinations of information supplied in an oath or declaration filed after the filing date are acceptable as minimums for identifying a specification and compliance with any one of the items below will be accepted as complying with the identification requirement of 37 CFR 1.63:

"(1) name of inventor(s), and application number (consisting of the series code and the serial number; e.g., 08/123,456);

"(2) name of inventor(s), serial number and filing date;

"(3) name of inventor(s) and attorney docket number which was on the specification as filed;

"(4) name of inventor(s), title which was on the specification as filed and filing date;

"(5) name of inventor(s), title which was on the specification as filed and reference to an attached specification which is both attached to the oath or declaration at the time of execution and submitted with the oath or declaration; or

"(6) name of inventor(s), title which was on the specification as filed and accompanied by a cover letter accurately identifying the application for which it was intended by either the application number (consisting of the series code and the serial number; e.g., 08/123,456), or serial number and filing date. Absent any statement(s) to the contrary, it will be presumed that the application filed in the PTO is the application which the inventor(s) executed by signing the oath or declaration."

Notice of July 13, 1995 (1177 O.G. 60).

(c) ☐ was described and claimed in PCT International Application No. \_\_\_\_\_, filed on \_\_\_\_\_ and as amended under PCT Article 19 on \_\_\_\_\_ (if any).

**SUPPLEMENTAL DECLARATION (37 C.F.R. § 1.67(b))**

*(complete the following where a supplemental declaration is being submitted)*

- ☐ I hereby declare that the subject matter of the
- ☐ attached amendment
- ☐ amendment filed on \_\_\_\_\_

was part of my/our invention and was invented before the filing date of the original application, above-identified, for such invention.

**ACKNOWLEDGEMENT OF REVIEW OF PAPERS AND DUTY OF CANDOR**

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information, which is material to patentability as defined in 37, Code of Federal Regulations, § 1.56,

*(also check the following items, if desired)*

☒ and which is material to the examination of this application, namely, information where there is a substantial likelihood that a reasonable Examiner would consider it important in deciding whether to allow the application to issue as a patent, and

☐ in compliance with this duty, there is attached an information disclosure statement, in accordance with 37 CFR 1.98.

**PRIORITY CLAIM (35 U.S.C. §§ 119(a)-(d))**

**NOTE:** "The claim to priority need be in no special form and may be made by the attorney or agent if the foreign application is referred to in the oath or declaration as required by § 1.63. The claim for priority and the certified copy of the foreign application specified in 35 U.S.C. 119(b) must be filed in the case of an interference (§ 1.630), when necessary to overcome the date of a reference relied upon by the examiner, when specifically required by the examiner, and in all other situations, before the patent is granted. If the claim for priority or the certified copy of the foreign application is filed after the date the issue fee is paid, it must be accompanied by a petition requesting entry and by the fee set forth in § 1.17(f). If the certified copy is not in the English language, a translation need not be filed except in the case of interference; or when necessary to overcome the date of a reference relied upon by the examiner; or when specifically required by the examiner, in which event an English language translation must be filed together with a statement that the translation of the certified copy is accurate." 37 C.F.R. § 1.55(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §§ 119(a)-(d) of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

*(complete (d) or (e))*

- (d) ☒ no such applications have been filed.
- (e) ☐ such applications have been filed as follows.

**NOTE:** Where item (c) is entered above and the International Application which designated the U.S. itself claimed priority check item (e), enter the details below and make the priority claim.

**PRIOR FOREIGN/PCT APPLICATION(S) FILED WITHIN 12 MONTHS  
(6 MONTHS FOR DESIGN) PRIOR TO THIS APPLICATION  
AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. § 119(a)-(d)**

COUNTRY (OR INDICATE IF PCT)	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 37 USC 119
			<input type="checkbox"/> YES    NO <input type="checkbox"/>
			<input type="checkbox"/> YES    NO <input type="checkbox"/>
			<input type="checkbox"/> YES    NO <input type="checkbox"/>
			<input type="checkbox"/> YES    NO <input type="checkbox"/>
			<input type="checkbox"/> YES    NO <input type="checkbox"/>

**CLAIM FOR BENEFIT OF PRIOR U.S. PROVISIONAL APPLICATION(S)**  
(34 U.S.C. § 119(e))

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below:

**PROVISIONAL APPLICATION NUMBER**

**FILING DATE**

\_\_\_\_ / \_\_\_\_ / \_\_\_\_  
 \_\_\_\_ / \_\_\_\_ / \_\_\_\_  
 \_\_\_\_ / \_\_\_\_ / \_\_\_\_

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

**CLAIM FOR BENEFIT OF EARLIER US/PCT APPLICATION(S)**  
**UNDER 35 U.S.C. 120**

- ☐ The claim for the benefit of any such applications are set forth in the attached ADDED PAGES TO COMBINED DECLARATION AND POWER OF ATTORNEY FOR DIVISIONAL, CONTINUATION OR CONTINUATION-IN PART (C-I-P) APPLICATION.

**ALL FOREIGN APPLICATION(S), IF ANY, FILED MORE THAN 12 MONTHS  
(6 MONTHS FOR DESIGN) PRIOR TO THIS U.S. APPLICATION**

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**NOTE:** If the application filed more than 12 months from the filing date of this application is a PCT filing forming the basis for this application entering the United States as (1) the national stage, or (2) a continuation, divisional, or continuation-in-part, then also complete **ADDED PAGES TO COMBINED DECLARATION AND POWER OF ATTORNEY FOR DIVISIONAL, CONTINUATION OR C-I-P APPLICATION** for benefit of the prior U.S. or PCT application(s) under 35 U.S.C. § 120.

**POWER OF ATTORNEY**

I hereby appoint the following practitioner(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

*(list name and registration number)*

Clarence A. Green	24,622	Janik Marcovici	42,841
Mark F. Harrington	31,686	Harry F. Smith	32,493

*(check the following item, if applicable)*

- ☐ I hereby appoint the practitioner(s) associated with the Customer Number provided below to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.
- ☐ Attached, as part of this declaration and power of attorney, is the authorization of the above-named practitioner(s) to accept and follow instructions from my representative(s).

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**SEND CORRESPONDENCE TO**

**DIRECT TELEPHONE CALLS TO:**  
*(Name and telephone number)*

☒ **Address**

PERMAN & GREEN, LLP  
425 Post Road  
Fairfield, CT 06430

Janik Marcovici  
(203) 259-1800

☐ **Customer Number** \_\_\_\_\_

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## DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

## SIGNATURE(S)

NOTE: Carefully indicate the family (or last) name, as it should appear on the filing receipt and all other documents.

Full name of sole or first inventor

Christopher \_\_\_\_\_ A. \_\_\_\_\_ Hofmeister \_\_\_\_\_  
(GIVEN NAME) (MIDDLE INITIAL OR NAME) FAMILY (OR LAST NAME)

Inventor's signature \_\_\_\_\_

Date 9-25-98 Country of Citizenship USA

Residence Hampstead, New Hampshire

Post Office Address 176 Wheetwright Road  
Hampstead, New Hampshire 03841

Full name of second joint inventor, if any

\_\_\_\_\_  
(GIVEN NAME) (MIDDLE INITIAL OR NAME) FAMILY (OR LAST NAME)

Inventor's signature \_\_\_\_\_

Date \_\_\_\_\_ Country of Citizenship \_\_\_\_\_

Residence \_\_\_\_\_

Post Office Address \_\_\_\_\_

Full name of third joint inventor, if any

\_\_\_\_\_  
(GIVEN NAME) (MIDDLE INITIAL OR NAME) FAMILY (OR LAST NAME)

Inventor's signature \_\_\_\_\_

Date \_\_\_\_\_ Country of Citizenship \_\_\_\_\_

Residence \_\_\_\_\_

Post Office Address \_\_\_\_\_

(check proper box(es) for any of the following added page(s)  
that form a part of this declaration)

- ☐ **Signature** for fourth and subsequent joint inventors. *Number of pages added* \_\_\_\_\_

\* \* \*

- ☐ **Signature** by administrator(trix), executor(trix) or legal representative for deceased or incapacitated inventor. *Number of pages added* \_\_\_\_\_

\* \* \*

- ☐ **Signature** for inventor who refuses to sign or cannot be reached by person authorized under 37 CFR 1.47. *Number of pages added* \_\_\_\_\_

\* \* \*

- ☐ Added page for **signature** by one joint inventor on behalf of deceased inventor(s) where legal representative cannot be appointed in time. (37 CFR 1.47)

\* \* \*

- ☐ Added pages to combined declaration and power of attorney for divisional, continuation, or continuation-in-part (C-I-P) application.

☐ Number of pages added \_\_\_\_\_

\* \* \*

- ☐ Authorization of practitioner(s) to accept and follow instructions from representative.

\* \* \*

(if no further pages form a part of this Declaration,  
then end this Declaration with this page and check the following item)

- ☒ This declaration ends with this page.